

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (Currently amended) An ultrasonic surgical system including a controllable ultrasonic energy generator, a hand piece with a blade that is vibrated at an ultrasonic resonance frequency rate by energy from the generator, and a switch for indicating to the generator the amplitude and frequency of the energy supplied to the hand piece, said ultrasonic generator comprising:

an analog input drive signal generator which generates an input drive signal having an amplitude and frequency;

an amplifier which receives the analog input drive signal and supplies the energy [[to]] through a transformer and the transformer output is fed to the hand piece through a line in response thereto;

a current sensor that senses the current [in the line] at the transformer output and produces a current signal related thereto;

a comparator which compares the current signal to a variable preset current value and produces a difference signal that is applied to the analog input drive signal generator so as to change the amplitude of the drive signal to cause the current signal to match the preset value;

a voltage sensor which senses the voltage[on the line] at the transformer output and produces a voltage signal related thereto;

a digital phase detector which compares the current signal to the voltage signal and generates a digital phase code related to the phase difference between them;

a digital impedance detector which compares the ratio of the voltage signal to the current signal and generates a digital impedance code related thereto;

a digital controller which receives the digital phase code and the digital impedance code and produces a digital frequency code in response thereto which is at a frequency which represents the resonance of the hand piece; and

a direct digital synthesis circuit for converting the digital frequency code to an analog frequency signal that is applied to the analog input drive signal generator so as to maintain the frequency at the resonance frequency.

2. (Original) The ultrasonic surgical system of claim 1 further including a controlled power supply for said amplifier which supplies power at a level to assure efficient operation of said amplifier.

3. (Original) The ultrasonic surgical system of claim 2 wherein the controlled power supply comprises:

a fixed reference voltage;
a comparator which compares the output of the amplifier to the fixed reference voltage and generates a power control signal in response thereto;

an adjustable Buck regulator receiving a supply of power at one level and producing a supply of power at a different level based on the power control signal, the power at the different level being supplied to the amplifier.

4. (Original) The ultrasonic surgical system of claim 3 wherein the output of the amplifier is connected to said comparator by a loop filter.

5. (Original) The ultrasonic surgical system of claim 1 wherein the digital phase detector comprises:

a voltage signal zero crossing detector which produces a voltage zero signal when said voltage signal crosses a zero axis;

a current signal zero crossing detector which produces a current zero signal when said current signal crosses a zero axis;

a circuit for measuring the time between the voltage zero signal and the current zero signal and producing a digital code related thereto.

6. (Original) The ultrasonic surgical system of claim 1 wherein the digital impedance detector comprises:

a voltage averaging circuit which produces a voltage average signal based on the said voltage signal;

a current averaging circuit which produces a current averaging signal based on said current signal; and

wherein said digital controller continuously generates the ratio of the voltage average signal to the current average signal as an impedance signal, and wherein a change in said impedance signal as the drive signal frequency changes indicates an approach to said resonance frequency.

7. (Original) The ultrasonic surgical system of claim 1 further including a power level switch circuit which determines the preset current level.

8. (Original) The ultrasonic surgical system of claim 7 wherein the power level switch circuit comprises:

a power level switch connected to said digital controller and causing said digital controller to produce a digital current level signal;

a digital-to-analog convertor for changing the digital current level signal into an analog current level signal;

a current averaging circuit which produces a current average signal based on the said current signal from said current sensor;

a current comparator which compares the analog current level signal and the average current signal and produces an amplitude control signal, said amplitude control signal which is applied to the direct digital synthesis circuit to vary the amplitude of the analog frequency signal.

9. (Original) The ultrasonic surgical system of claim 8, wherein said analog input drive signal generator comprises a comparator which compares the analog frequency signal from the direct digital synthesis circuit and the current signal from the current sensor to produce the input drive signal of the amplifier.

10. (Original) The ultrasonic surgical system of claim 1, wherein during start up of the system causes the amplifier to generate an ultrasonic signal at a frequency near resonance, and to increment the frequency toward resonance while monitoring the outputs of said digital phase detector and digital impedance detector, and to halt the incrementing when these outputs indicate resonance of the hand piece.

11. (Original) The ultrasonic surgical system of claim 1 further including a memory which stores the maximum current to be delivered to a hand piece, and wherein the digital controller compares the average current signal to the maximum and halts the supply of energy to the hand piece when the average current exceeds the maximum.

12. (Original) The ultrasonic surgical system of claim 1 where in the digital controller includes a program which causes the amplifier to supply different current and voltage levels to the hand piece at different frequencies and to measure the current, voltage and phase to diagnose and test the operation of the system.

13. (Original) The ultrasonic surgical system of claim 12 further including a console for housing the generator, said console having a front panel, and wherein the diagnoses and testing is implemented in response to the activation of a button on the front panel and one of a foot pedal switch and a hand piece switch.

14. (Original) The ultrasonic surgical system of claim 1 further including a electrical interference detector which produces an output in response to the operation of an Electro-surgical Unit in the vicinity, and wherein the digital controller halts operation of the system in response to an output from said interference detector.